REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(LEAVE BLANK)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	2 February 1998	Professional Paper

4. TITLE AND SUBTITLE

Testing and Proving the GBU-24 Laser-Guided Bomb from the U.S. Navy's F-14 Aircraft

5. FUNDING NUMBERS

6. AUTHOR(S)

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Air Systems Command
47123 Buse Road, Unit IPT
Patuxent River, Maryland 20670-1547

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13. ABSTRACT *(Maximum 200 words)*

When the U.S. Navy identified the requirement to carry and employ the Texas Instruments-Raytheon GBU-24 Laser Guided Bomb (LGB) hard target penetrator from the F-14 aircraft, its weapons compatibility/certification engineers had to modify the weapons flight test process which had been in use for determination of aircraft and air-to-ground (A/G) weapons compatibility. That process consisted of beginning test at low Mach/Airspeed in straight and level flight, and continuing tests, at incrementally greater speeds, through the highest Mach/airspeed and steepest fligh path angles, with the acceptability of the weapon separation trajectory evaluated through film from aircraft-mounted cameras. The GBU-24, because of its large size and large deploying wing, had to be evaluated through an integrated test and evaluation process consisting of Computational Fluid Dynamics (CFD) analyses, wind tunnel testing, ground testing, flight testing and photogrammetric analyses, used interdependently, to determine the extent of aircraft/weapon compatibility. The test process ultimately led to the authorization for all F-14 variants to carry and employ two GBU-24's on fuselage carriage stations. In addition, the testing led to authorization for launching of an AIM-7 air-to-air missile from a fuselage carriage station which was behind the LGB A/G weapons.

14. SUBJECT TERMS	15. NUMBER OF PAGES
GBU-24 laser guided bomb (LGB) F-14	9
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

TESTING AND PROVING THE GBU-24 LASER-GUIDED BOMB FROM THE U.S. NAVY'S F-14 AIRCRAFT

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Abstract

When the U.S. Navy identified the requirement to carry and employ the Texas Instruments-Raytheon GBU-24 Laser Guided Bomb (LGB) hard target penetrator from the F-14 aircraft, its weapons compatibility/certification engineers had to modify the weapons flight test process which had been in use for determination of aircraft and Air-to-Ground (A/G) weapons compatibility. That process consisted of beginning tests at low Mach/airspeed in straight and level flight, and continuing tests, at incrementally greater speeds, through the highest Mach/airspeed and steepest flight path angles, with the acceptability of the weapon separation trajectory evaluated through film from aircraft-mounted cameras. The GBU-24, because of its large size and large deploying wing, had to be evaluated through an integrated test and evaluation process consisting of Computational Fluid Dynamics (CFD) analyses, wind tunnel testing, ground testing, flight testing and photogrammetric analyses, used interdependently, to determine the extent of aircraft/weapon compatibility. The test process ultimately led to the authorization for all F-14 variants to carry and employ two GBU-24's on fuselage carriage stations. In addition, the testing led to authorization for launching of an AIM-7 Air-to-Air missile from a fuselage carriage station which was behind the LGB A/G weapons.

Symbols

ALPHA	Angle of attack
C.G.	Center of Gravity
Cm	Pitching moment coefficient about C.G.
CN	Normal force coefficient
Cn	Yawing moment coefficient about C.G.
G	Acceleration due to gravity, 32 ft/sec/sec
GBU	Guided Bomb
KCAS	Knots Calibrated Airspeed
LGB	Laser Guided Bomb
M	Mach Number
P	Weapon roll rate, positive right wing down, deg/sec
PHI	Weapon roll angle, positive right wing down, degrees
PSI	Weapon yaw angle, positive nose right, degrees
Q	Weapon pitch rate, positive nose up, deg/sec
R	Weapon yaw rate, positive nose right, deg/sec
THE	Weapon pitch angle, positive nose up, degrees
X	Weapon C.G. location, positive forward, ft.
Y	Weapon C.G. location, positive right, ft.
Z	Weapon C.G. location, positive down, ft.

Introduction

The U.S. Navy's F-14 Precision Strike Program was formulated to expand the A/G weapon delivery capability of the F-14A/B/D aircraft through inclusion of a self-contained precision weapons capability. To accomplish this, a Forward Looking Infrared sensor and Laser Designator were incorporated in the aircraft, and LGBs were tested on, and cleared for use with these aircraft. The GBU-24 was a particularly difficult LGB to test on the F-14 because of its minimal weapon/aircraft clearance, even in the carriage position, and because of its large deploying aft wing during the weapon's separation from the aircraft. Initial ground fit tests showed that, on the aft fuselage carriage stations, the GBU-24 wing housing (wing in stowed position) was only 2.75 inches from the engine nacelle!

Weapon separation wind tunnel testing was conducted with a 5% scale F-14 model in the Arnold Engineering Development Center's (AEDC) 4T transonic wind tunnel. The purpose of the test was to identify which, if any, F-14 weapons stations were suitable for carriage and separation of the GBU-24, how many GBU's could be carried simultaneously, and what length wing latch lanyard would be required to assure safe clearance of the deploying GBU-24 wing from the F-14's nacelles. The test was complicated by the need to account for a free-floating, spring-loaded canard on the nose of the GBU-24, and by the two-position opening sequence for the aft wing on the weapon. An additional purpose of the test was to determine whether an AIM-7 missile could be safely launched from behind a 2000 lb LGB.

Using the wind tunnel data, separation trajectories were calculated and used to formulate a flight test plan for determination of a safe separation/employment envelope, and to identify the appropriate length wing latch lanyard for weapon wing deployment.

Flight testing was conducted to prove the safe carriage and separation envelope, as well as aircraft carrier launch compatibility. 14 GBU's and 2 missiles were separated on 14 aircraft flights, leading to authorization for simultaneous carriage of two GBU-24's on diagonally opposed fuselage weapon stations, to supersonic Mach numbers and flight path angles down to 45 degrees for all F-14 variants, and for carriage/launch of an AIM-7 missile from behind forward-mounted LGB weapons.

Description of Aircraft

The F-14 Tomcat is a supersonic, two-seat, twin-engine, swing-wing air-superiority fighter designed and manufactured by the former Grumman Aerospace Corporation. The F-14A is powered by two Pratt and Whitney TF-30-P-414A engines and is fitted, primarily, with analog avionics. The F-14B has avionics similar to the F-14A but is powered by General Electric F110-GE-400 engines. The F-14D is also powered by F110-GE-400 engines, and is fitted with digital avionics and a dual chin pod designed to house the Infrared Search and Track System (IRST), as well as the Television Camera Set (TCS) which is also found in the F-14A/B single chin pod. For Air-to-Air missions all F-14 variants employ Phoenix, Sparrow, and Sidewinder missiles and an internal 20 mm cannon. For A/G missions all F-14 variants employ conventional ordnance. The A/G weapons are carried on four fuselage stations (stations 3, 4, 5 and 6 as shown in Figure 1) using weapon rails equipped with BRU-32 bomb racks. Cameras were installed on the test aircraft to record weapon separations. The test aircraft were representative of fleet aircraft. They were instrumented to provide telemetry and data recording of various aircraft, GBU-24, and AIM-7 missile parameters, including airspeed, angle-of-attack, accelerations, angular rates, and more.

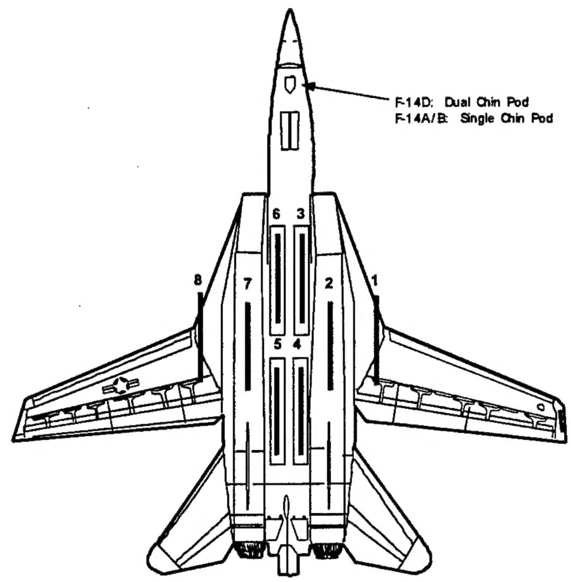

Figure 1. F-14 Aircraft Weapons Carriage Stations

Description of GBU-24

The GBU-24 is a 2000 lb class Paveway III LGB (third generation development of laser guided munitions) which homes on energy refelected off a target illuminated by a suitable airborne or ground laser designator. It consists of a forward-mounted guidance and control unit, a BLU-109 hard target penetrator warhead (which is thermally coated to reduce the hazard from fire), and an aft fairing which directs airflow around the aft airfoil group assembly. An adapter mounted to the top of the weapon consists of a hardback designed to interface with the F-14's BRU-32 bomb rack. The wings of the airfoil group, upon release, travel to 20 degrees deflection for the first two seconds and then extend fully to 70 degrees. Figure 2 depicts the weapon with its various components, and Table I identifies some of the weapon's key parameters.

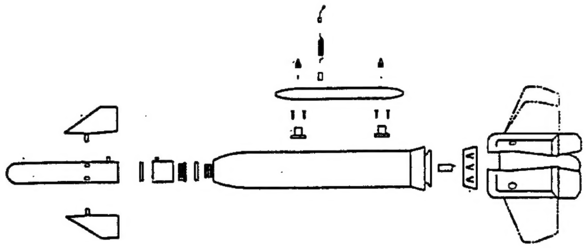

Figure 2. GBU-24 (Paveway III) LGB

Table 1 Key GBU-24B/B Parameters

Parameter	GBU-24B/B
Weight	2380 lb.
Store length	169.69 in. (14.14 ft.)
Canard Span	39.25 in.
Wing Span	wings stowed: 36.0 in. wings 20 deg: 55.75 in. wings 70 deg: 80.36 in.

When the weapon is released, the bomb rack ejects it away from the aircraft carriage station, pulling all lanyards and, thereby, activating the fuze, initializing the weapon and releasing the spring-loaded wings. For the first two seconds after release, the canards are free-floating

For the flight tests, Separation Test Vehicles (STV) were used, differing from the actual weapon only with respect to inert warheads and inert guidance and control units (with operationally representative canard control shafts).

Ground Tests

Initial fit tests of the weapon on the aircraft showed that the weapon's canards extended, laterally, beyond the aircraft fuselage centerline, resulting in canard overlap when weapons were loaded side-by-side. However, one GBU-24 on a forward station, and one on an aft station resulted in an acceptable fit. When loaded on station 5 (aft starboard), the horizontal clearance between aircraft nacelle and the GBU-24 upper outboard wing tip was 2.75 inches. The questions that needed resolution, then, were:

> Which combination of stations would be acceptable (stations 3 and 4, stations 3 and 5, stations 4 and 6, or stations 5 and 6)?
>
> What length wing latch lanyard was required, to assure clearance between the opening GBU-24 wing and the aircraft nacelle ? (Too long a lanyard could also pose a problem with respect to inducing a nose down pitching moment)

Testing by trial and error was clearly unacceptable due to risk and cost. Analytical computations of predicted separation trajectories were required, and wind tunnel data were needed as inputs to those computations.

Wind Tunnel Testing

A 5% scale wind tunnel model of the F-14 was available and used for this test; F-14A/B and D configurations were tested. In the AEDC 4T tunnel, the aircraft model is mounted inverted on a special support system attached to the floor of the test section. The weapon model is mounted on a separate sting which is attached to the top of the test section. The weapon can be placed at selected points from close to the actual carriage position to points clear of the aircraft interference flowfield to measure the forces and moments at those positions. The weapon support sting can also be moved, via computer calculated positions based on measured forces and moments, throughout the weapon's trajectory. Figure 3 shows the GBU-24 above the parent F-14 aircraft.

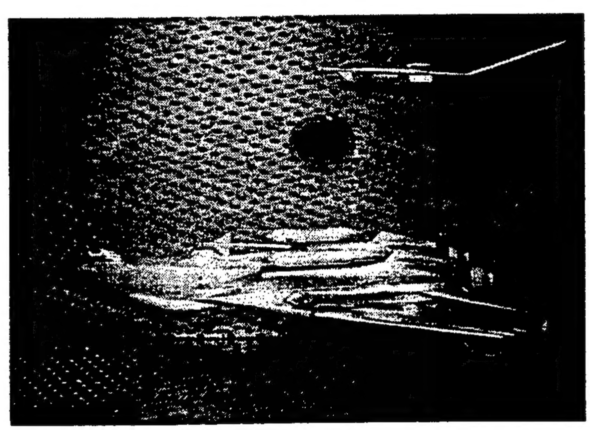

Figure 3. F-14/GBU-24 in AEDC 4T Wind Tunnel

Freestream Tests

Prior to installation of the aircraft model in the wind tunnel, freestream data were obtained with a 5% scale model of the GBU-24. At that small a scale it

was impossible to model the weapon's floating canards; the initial plan was to test the weapon with fixed canards, only. However, experience from previous U.S. Air Force compatibility testing of the F-15 aircraft and the GBU-24 had shown that GBU-24 wind tunnel testing required identical runs both with and without canards to quantify the effects of the floating canards on the trajectory. Subsequent U.S. Navy wind tunnel testing of another aircraft model, with 10% scale GBU-24's which actually had floating canards, showed that even at that larger scale it was not feasible to duplicate the dynamics of the canards. Three model configurations were, therefore, tested to gather freestream data:

a. Wing stowed, fixed canards
b. Wing stowed, canards off
c. Wings deployed 20 degrees, fixed canards

Captive Trajectory Tests

Prior to the wind tunnel entry a comprehensive test matrix had been formulated which was well in excess of the amount of testing actually required. Not knowing the direction of weapon yaw or lateral motion, not knowing the direction/magnitude of weapon pitch attitude, and not knowing which actual aircraft carriage stations would finally be used, the matrix had to account for all possibilities. Captive trajectory tests were conducted to answer some of those unknowns and to allow the matrix to be reduced. One of the most significant results of the captive carriage tests was the identification of aircraft stations 3 and 5 as the best combination for carriage of 2 weapons.

Carriage Loads and Grid Tests

The most critical parameters influencing a weapon's initial separation trajectory are the pitching, rolling and yawing moments at carriage. While some aerodynamicists choose to accept as carriage loads, the forces and moments measured on a weapon brought to the closest possible position near carriage by the wind tunnel's captive trajectory sting, U.S. Navy engineers have observed significant differences in loads measured at carriage versus "very close" to carriage for some designs. Therefore, carriage loads tests were obtained by mounting an instrumented weapon model in the actual carriage position. At the same time grid data were obtained for the store on the aircraft station not being tested for carriage loads. Grid sweeps were conducted at various pitch and yaw angles as determined from the captive trajectory tests. The GBU-24 configurations, for which grid data were measured, included canards-on , canards-off, wings-stowed and wings in the 20 degrees open position. On completion of the GBU-24 grid sweeps, an AIM-7 was mounted on the aft center fuselage station to measure carriage loads with 2000 lb LGB's on aircraft stations 3 and/or 6. Grid sweeps and captive trajectory tests were subsequently performed for the AIM-7, again with single or dual 2000 lb LGB's on the forward aircraft carriage stations. Figure 4 shows the F-14 model with the AIM-7 behind two 2000 lb LGB's.

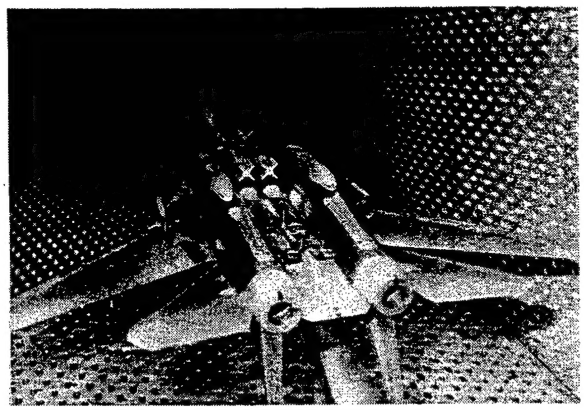

Figure 4. F-14/AIM-7 in AEDC 4T Wind Tunnel

Aircraft Static Ejection Tests

The two characteristics of the GBU-24 which greatly complicated the ability to analytically determine separation trajectories, even with wind tunnel data, were the free floating canards and the moving wings. It was felt that CFD analyses could be used to determine the local upwash and sidewash angles at the GBU-24 nose, and thus, could help in computing canard deflection angles. But given the complexity in getting to that point, accompanied by the uncertainty in the CFD results, it was decided to evaluate canard dynamics via the aircraft mounted cameras during flight testing. The wing opening effects, on the other hand, had to be well-defined prior to flight because of the criticality of preventing the wing from contacting the aircraft during separation. The GBU-24 manufacturer provided data regarding initial wing opening rate, and other data were available from F-18/GBU-24 compatibility flight tests. The average initial wing deployment delay was supposed to be 53 msec, and the

statistically fastest possible initial deployment rate was 300 deg/sec. To evaluate the opening dynamics more precisely, static ejection tests were conducted, and cameras used to record the movement of the weapon and its components. Twelve static ejections were conducted from aircraft station 5. Nine and eighteen inch wing latch deployment lanyards were selected for evaluation to provide approximately six and twelve inches of vertical weapon travel, respectively, prior to wing deployment. The extensions were built into the lanyards by either doubling up the extension and encasing it in heat shrink wrap, or by putting the extension into a loop and securing the loop with standard ordnance tape. In both cases, the lanyard pulled to its full extended length prior to pulling the wing deployment latch; the lanyards parted at a weak link, leaving a short length attached to the suspension unit, while the majority of the lanyard remained with the weapon. The photogrammetric data from these ejection tests were used to modify the 6 degrees of freedom separation model of the weapon. The tests led to final selection of the 9 inch extended lanyard for GBU-24's carried on aircraft station 5.

Captive Carriage Tests

Prior to separating the weapons from the F-14, in-flight, captive carriage flight tests were conducted through the flight envelope. To impose all foreseeable environments on the weapon, maneuvers included aircraft clean and dirty stalls, steady heading sideslips, pitch and yaw doublets, accelerated rolls, wind-up and wind-down turns, a throttle chop, a steady push, an acceleration run, a simulated dive delivery, and high dynamic pressure runs. Post flight evaluation of the onboard camera film showed no adverse canard motion, and all arming wires and lanyards returned intact. Following one captive carriage flight, weapon inspection revealed failure of the aircraft station 5 GBU-24 metal retaining ring which surrounded the forward part of the aft fin fairings; the failure occurred at the screw clamp resulting in detachment of the band and separation from the store. The extended wing release lanyard bound under the fairing. Weapons were tested on aircraft stations 3 and 5 for several further hours. No additional problems were evidenced and the damage on the first flight was subsequently deemed to be an anomaly. Authorization was given to proceed with separation flight testing, with carriage up to supersonic airspeeds/Mach Numbers.

Separation Flight Tests

For the flight testing, data were obtained from aircraft mounted high-speed cameras, aircraft onboard instrumentation (recorded onboard as well as telemetered), a sensor unit installed in the weapon tail fuze well, cinetheodolites and ground tracking mounts, chase aircraft cameras, and aircrew recorded data. The sensor unit in the weapon provided three axes accelerations and pitch, roll and yaw rates. During the flights the aircraft parameters were observed real-time, as were weapon accelerations and angular rates. The camera films provided the time histories of the weapon motion following release; the aircraft and weapons were marked with photo targets to permit photogrammetric analysis after the flight.

Figure 5 depicts the cameras and their locations on the aircraft. The cameras located at stations 2 and 7 were housed in converted fuel tanks, referred to as Fuel Tank Camera Pods (FTCP). A flash system was used to detect initial weapon motion; it improved he photogrammetric analysis/solution by correlating first movement, viewed via the cameras, with and without event markers. The onboard cameras provided the bulk of the separation data. All cameras were Photosonic Model 1PL except for the nose cameras, which were Photosonic Model 1VN. Camera speed was 200 frames per second and provided approximately 40 secs of film run time. All aircraft cameras, except the nose camera, had Interservice Range Instrumentation Group (IRIG) standard time displayed on the film for accurate data correlation.

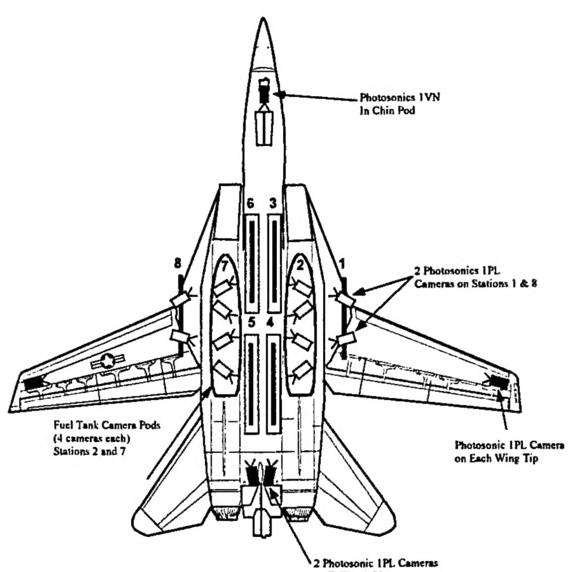

Figure 5. F-14 Test Aircraft Camera Locations

Detailed evaluation of the various wind tunnel configurations and worst case trajectory predictions, considering canard deflection and wing position, showed that separation of a GBU-24 from aircraft station 3 at M=.82 would be a minimal risk test point. Thus the first flight test was a separation from station 3 at 500 KCAS, M=0.8.

Figure 6 shows a comparison of the predicted weapon attitudes, during separation, with the attitudes obtained through integration of the rates telemetered from the weapon sensor unit. The prediction was computed by using the canards-on wind tunnel test data. U.S. Navy past experience has shown that, typically, it is very difficult to match weapon roll attitude precisely, and so the roll mismatch did not cause concern. On the other hand, pitch and yaw can be matched extremely well, and the prediction, in this case, was unsatisfactory due to the significant mismatch in pitch.

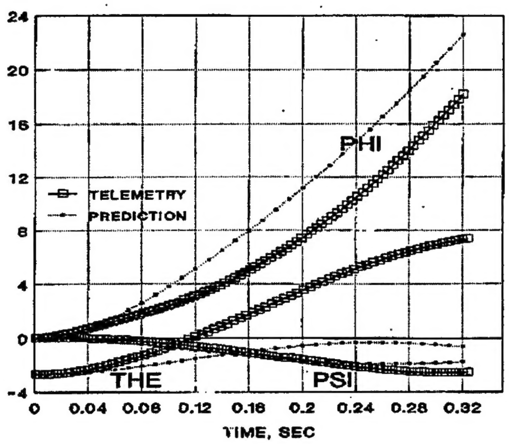

Figure 6. GBU-24/F-14 Station 3 Trajectory

Since the difference in pitch attitude could, perhaps, have been attributable to the canard effect, a predicted trajectory was computed with the canards-off wind tunnel data. Figure 7 shows the difference in freestream characteristics between the canards-on and canards-off configurations. Removing the canards changes the weapon's pitch characteristics from unstable to stable, although the normal force does not change significantly.

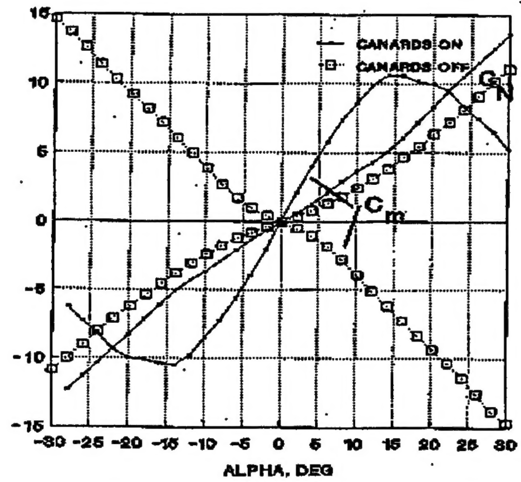

Figure 7. GBU-24 Freestream Wind Tunnel Data

Figure 8 shows the comparison between predicted and actual angular rates using canards-off data for the prediction. Note that the trajectories account for wing deployment; the wings open between 85 msec (0.6 ft) and 170 msec (2.0 ft). The grid and freestream data were interpolated, linearly, during the opening sequence, between the wings-stowed data and the wings-deployed 20 degrees data.

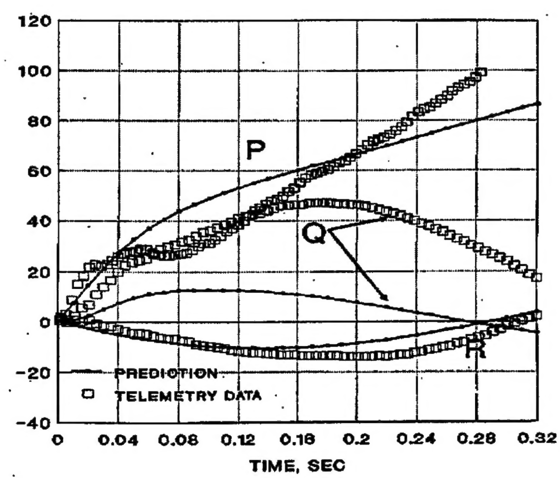

Figure 8. GBU-24/F-14 Station 3 Angular Rates

The poor match in pitch rate was attributed to the aircraft flowfield effect on the canards. Flight test film showed that the canards were deflected nose up in carriage, indicative of a download on the nose of the weapon. Seeking to account for the load on the canards, the canards-off grid pitching moment coefficient was incrementally increased until predicted and actual pitch rates matched. Figure 9

compares the modified predicted angular rates with flight test results.

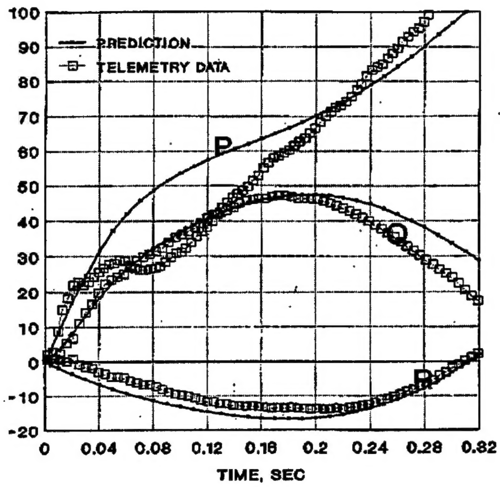

Figure 9. GBU-24/F-14 Station 3 Angular Rates

The corresponding weapon attitudes are compared in Figure 10. The pitch and yaw matches were quite good; predicted roll attitude was approximately 2 degrees greater than was actually experienced in flight.

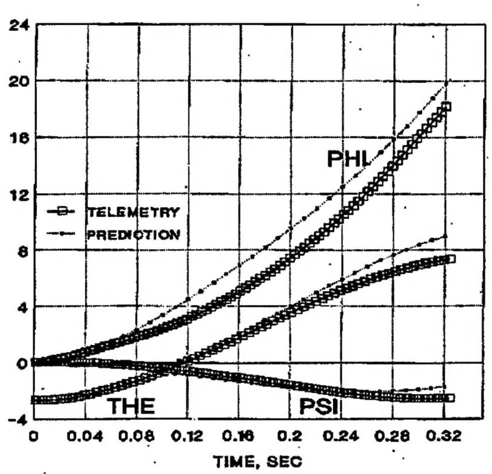

Figure 10. GBU-24/F-14 Station 3 Trajectory

To gain confidence in the validity of analytically predicted trajectories for other flight conditions, the next flight test was conducted at M=0.9. Using the same incremental pitching moment coefficient, based on observation of canard nose-up deflection in carriage at the release condition, angular rates and attitudes were computed and compared with flight test results, with very similar results to those shown above. The weapon again pitched up, with negligible yaw, and a roll build-up due to the weapon wing geometry.

Acceptability of a separation trajectory is well-defined in MIL-STD-1763A (Ref 1), in terms of weapon miss distance from the aircraft and other weapons. The Standard requires that a weapon have positive movement away from the aircraft, and that no portion of the weapon penetrate a predetermined interference boundary of the aircraft (including remaining suspension/release equipment and other weapons. The boundary is defined by a 6 inch encapsulation of the aircraft (in the immediate area where separation is occurring), the ejection rack, and any adjacent weapons. Portions of the weapon already inside the boundary, when in the carriage position, are prohibited from further encroachment. Once outside the boundary, no part of the weapon may re-enter the boundary. Figure 11 shows the actual miss distances for both flights, based on photogrammetrics, and the prediction for the 2nd flight.

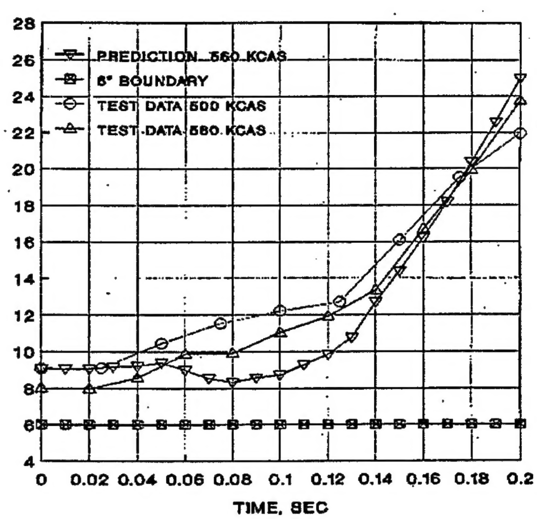

Figure 11. GBU-24/F-14 Station 3 Miss Distances

The conservative prediction seen in the Figure was also seen throughout the test program; predicted miss distances were always somewhat less than actual flight test results, giving confidence to making decisions based on the analytical results. One explanation for the difference is that aircraft motion in reaction to the weapon ejection was not accounted for; predicted weapon trajectories were based on the assumption that the aircraft was fixed in space.

Flight tests were conducted through the transonic and supersonic speed ranges, and all of the separations

from aircraft station 3 were characterized by an initial nose-up pitching moment, negligible yaw, and increasing roll. The separation trajectories remained outside the 6 inch boundary of the MIL-STD, leading to a recommendation to authorize operational use of the weapon on aircraft station 3.

Station 5 separations were higher risk than station 3 because of the weapon's close proximity to the engine nacelle and the extended length wing latch lanyard. M= 0.8 was again selected as the first flight test point, to gain confidence in the validity of the predicted trajectories by releasing at a minimum risk flight condition. The salient characteristics of the separation were a nose-up pitch of approximately one-half the magnitude of that on station 3, a yaw (nose-inboard) approximately 4 times greater than that on station 3, a lateral translation towards the center of the aircraft, and an increased delay in initial wing deployment. The extended lanyard introduced approximately 175 msec delay before wing opening. The analytical trajectory prediction, like that on station 3, was not an acceptable match. The canards-off grid data again provided a closer match than did the canards-on data, but incremental perturbation of the pitching moment and yawing moment coefficients was required to match predicted angular rates to the measured angular rates. The closest match in rates, and, hence, attitudes was obtained with a delta of 1.0 added to the pitching moment, and -2.5 added to the yawing moment. Figure 12 is a comparison of the predicted and measured attitudes.

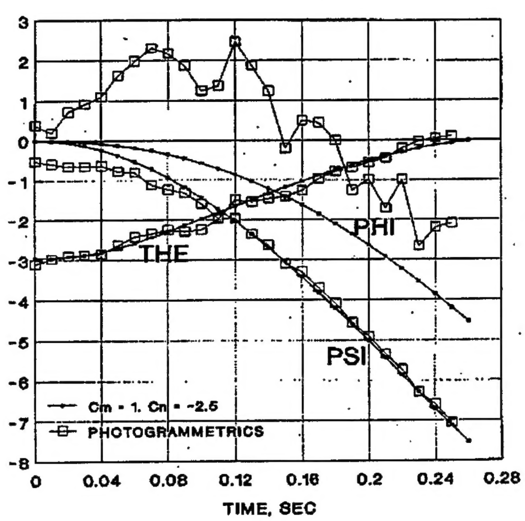

Figure 12. GBU-24/F-14 Station 5 Trajectory

The roll attitudes did not match, but the differences were again small in magnitude. Figure 13 compares the flight test measured miss distance with the predicted miss distances using both canards-on and canards-off grid data. The separation trajectory meets the requirements of MIL-STD-1763A, since the weapon has positive movement away from the aircraft.

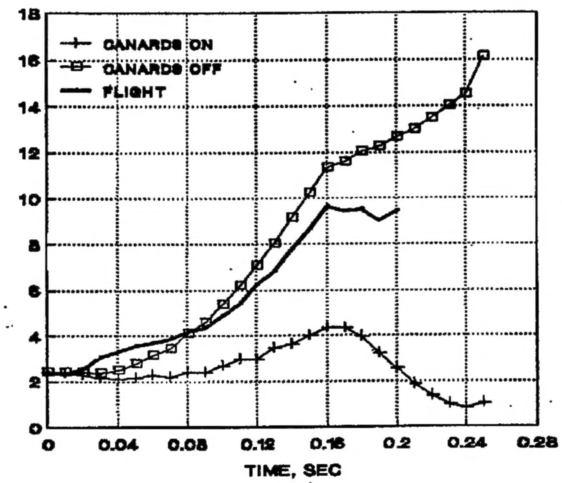

Figure 13. GBU-24/F-14 Station 5 Miss Distances

Flight tests for station 5 separations were conducted through the transonic and supersonic speed regimes. Using the same constant deltas in pitching moment and yawing moment, as previously noted, and using the canards-off grid data, predictions matched flight test attitudes and miss distances extremely well. All trajectories remained within the requirements of MIL-STD-1763A and led to authorization for operational use of the GBU-24 on aircraft station 5.

The overall lessons learned from this test program were:

> For a weapon with free-floating canards, it is essential to perform wind tunnel tests of the weapon without canards, when conducting separation grid tests
>
> When testing for carriage loads data for the same weapon, however, the canards must be on the weapon

An additional goal of this program was to determine the extent of AIM-7 missile compatibility with the F-14 aircraft, when carried and launched from the aft fuselage centerline station, given a 2000 lb LGB on

one or both of the forward aircraft stations. Based on previous experience with the F-14, this was a configuration which could not be proven by simply flight testing. The two types of 2000 lb LGB's authorized for use on the F-14 were considered: GBU-24 and GBU-10. (The GBU-10 is a 2000 lb class Paveway II LGB). In the case of the former, a single weapon on aircraft station 3 had been tested in the wind tunnel, and dual GBU-10's on stations 3 and 6, with the AIM-7 in the aft missile station. The AIM-7 was tested for freestream data, carriage loads, captive trajectories and grid data. The most critical mixed weapons configuration, from a separation consideration was found, from the wind tunnel data, to be dual GBU-10's on stations 3 and 6. Two flight tests were performed; the first at transonic speed, the second at supersonic speed. Since the missile did not have floating canards or a deploying wing, the analysis problem was relatively simple and straightforward. The only complexity, really, was modeling the missile's control system for the aircraft/weapon separation part of its flight envelope. Figure 14 shows a comparison of the measured roll and pitch attitudes, and the attitudes predicted with the wind tunnel data. There was no yaw.

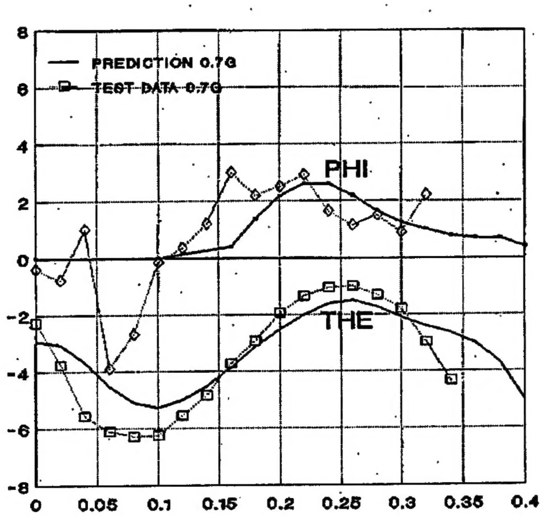

Figure 14. F-14/AIM-7 Trajectory

Figure 15 compares the measured and predicted vertical and longitudinal displacements of the missile during one of its launches (in a 45 degree dive).

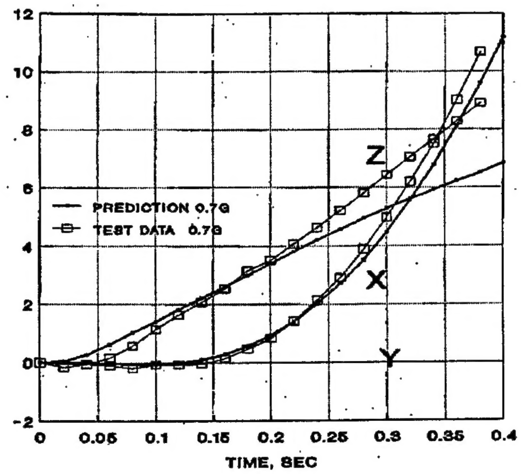

Figure 15 F-14/AIM-7 Trajectory

Conclusion

Determining the extent of compatibility of the GBU-24 with the F-14, and of the AIM-7 missile with the F-14, given 2000 lb LGB's in front of the missile, was a task which could not be accomplished by the old "cut and try" method of testing because of unacceptable risk and cost. Using a combination of computational analyses, wind tunnel testing, ground testing, flight testing and photogrammetric analyses, the U.S. Navy's compatibility/certification engineers were able to clear the GBU-24 for operational use on the F-14. A relatively small number of test assets and test flights were used in clearing the final, large employment envelope; carriage of multiple GBU-24's, and GBU-24 in combination with an AIM-7 missile was also successfully proven.

References

1. MIL-STD-1763A, Military Standard, Aircraft/Store Certification Procedures, 15 June 1992